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U.S. DEPARTMENT OF TRANSPORTATION

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AIRCREW PERFORMANCE ENHANCEMENT AND ERROR REDUCTION (APEER)

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16. Abstract

Historically, pilot error is involved as a factor in approximately 60% of air carrier and 88% of general aviation fatal accidents. Pilot error, however, is only a symptom of an underlying disease in the design and operation of the aviation system, including the aircraft, the ATC system, and institutional factors affecting aviation. In order to minimize errors commited in the cockpit, it is necessary to intensify our efforts to see that human capabilities and limitations are an integral consideration in the design and implementation of our future aviation systems.

The (APEER) program is a systems engineering approach to pilot error problems, which complements the human-oriented research that is conducted by the FAA's Office of Aviation Medicine. The objectives of the program are to develop information and principles for the design of cockpit and ground systems which: (1) induce the minimum number of errors by designing for maximum man/machine compatibility, and (2) resist the occurrence of chains of events leading to catastropic results by designing in error tolerance. An additional objective is to build up additional internal FAA expertise in the human factors area in order to better support FAA regulatory and other safety functions in this critical area.

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AIRCREW PERFORMANCE ENHANCEMENT AND ERROR REDUCTION

(APEER)

TECHNICAL PAPER

Background

In December, 1974, a TWA 727 crashed into Mount Weather just west of Dulles Airport because the pilot misunderstood certain critical parts of his clearance. A subsequent special Task Force formed by the DOT to study the FAA safety mission recommended that the "FAA undertake a major safety research program to assure that future systems are designed around reasonable criteria for human error." Meanwhile, the FAA Office of Systems Engineering Management had undertaken an in-house study to identify the human factors problems associated with both air carrier and general aviation accidents and incidents. The results of this study were briefed to industry and government groups and the feedback used to formulate a program of human factors research to supplement a number of ongoing FAA projects specifically aimed at reducing pilot error. These ongoing and new projects were pulled together under a central focal point and entitled the Aircrew Performance Enhancement and Error Reduction, or APEER, program.

Introduction

Historically, pilot error is involved as a factor in approximately 60% of air carrier and 88% of general aviation fatal accidents. Recent data from the NASA Aviation Safety Reporting System indicates that pilot error is also a significant factor in aviation incidents. Further, as aircraft powerplants, airframes, and systems improve, and as aircraft flight envelopes open to higher performance capabilities and lower minimums, the occurrence and consequences of pilot error are expected to increase in proportion to other factors.

Pilot error, however, is only a symptom of an underlying disease in the design and operation of the aviation system, including the aircraft, the ATC system, and institutional factors affecting aviation. In order to minimize errors committed in the cockpit, it is necessary to intensify our efforts to see that human capabilities and limitations are an integral consideration in the design and implementation of our future aviation systems.

Objectives

The APEER program is a systems engineering approach to pilot error problems, which complements the human-oriented research that is conducted by the FAA's Office of Aviation Medicine. The objectives of the program are to develop information and principles for the design of cockpit

and ground systems which: 1) induce the minimum number of errors by designing for maximum man/machine compatibility, and 2) resist the occurrence of chains of events leading to catastrophic results by designing in error tolerance. An additional objective is to build up additional internal FAA expertise in the human factors area in order to better support FAA regulatory and other safety functions in this critical area.

Program Overview

Human factors projects falling under the purview of the APEER program are being executed by the FAA's Office of Systems Engineering Management (OSEM), the Systems Research and Development Service (SRDS), the National Aviation Facilities Experimental Center (NAFEC), numerous FAA contractors, and jointly with NASA, in several cases. One of the joint projects with NASA is designed to study various distributions of responsibility for ATC functions between the pilot and controller, and other advantages and disadvantages associated with cockpit traffic displays. Other major projects in the APEER program include:

Cockpit Information Requirements Analytical Study

This project will analytically project the impact of the evolving ATC system and evolving aircraft systems on the information requirements of the flight crew. A request for proposals for this study has closed and several excellent bids have been received. Results should be available 13 months after contract award.

Cockpit Systems Integration

Ground-based system improvements currently under development by FAA and aircraft system improvements being developed by NASA and the industry will put much more information in aircraft cockpits in the future. The project above is designed to analytically study and collate these information requirements, but work is also needed to develop means of handling the information in the cockpits of conventionally instrumented and electronically instrumented aircraft. A project is being planned, jointly with NASA, to study information integration concepts for conventional and advanced aircraft.

General Aviation Human Factors Study

Although the original APEER analysis identified a number of specific general aviation human factors problem areas, many of which are currently being addressed as part of other projects, a more in-depth study is needed to refine the analysis and prioritize future research requirements. A contract is being awarded for such an in-depth study, to include general aviation accident and incident data, literature search, and industry survey. The RFP for this study has closed and bids are being evaluated.

Full-System Simulation

A significant portion of aircraft accidents and incidents involving human factors problems are associated with the interface between the pilot and the air traffic control system. A very effective technique for studying and solving these problems, known variously as full-system or full-mission simulation, has been developed by NASA and the airlines. However, a full-system simulation capability involving engineering simulators and a full-capability air traffic control system simulation does not currently exist. The purpose of this project is to tie various engineering simulators in NASA, which represent a wide spectrum of aircraft classes and types, to an extensive ATC simulation capability at NAFEC, thus creating the opportunity to study human factors problems in an operationally realistic, pilot-and-controller-in-the-loop environment. This capability will first be used, and is being developed as part of the cockpit traffic display program, but is expected to have a plethora of other uses related to human factors investigations.

Pilot Workload Assessment

One of the most difficult, yet important human factor problems presently facing researchers is the reliable, accurate, and consistent measure of pilot workload. Of the many techniques used today, simply asking the pilot how hard he is working is still one of the most trusted and widely used methods. However, the Cooper-Harper rating scale currently in use to quantify pilot subjective workload assessments was developed when cockpit workload was a function primarily of aircraft handling qualities. The FAA is currently developing and validating through a grant with the Massachusetts Institute of Technology, a new subjective rating scale based on ATC-oriented workload for use in human factor investigations.

Computer-Aided Decision Making

The intent of this project is to examine the potential for using artificially intelligent computer technology to implement a strategy of "adaptive automation" in a highly automated cockpit. A grant has been awarded to the University of Illinois to study the implications of using an artificially intelligent computer interactively with a flight crew in such a way that the functions performed automatically by the computer are not fixed, but are adapted to the particular flight situation so as to prevent both overload and underload of the crew.

General Aviation Human Factor Research Laboratory

General aviation operations are currently the most significant of all growth areas in aviation. The significant growth in general aviation operations under Instrument Flight Rules (IFR) are a particularly important trend because it means that low-cost, simplified ways of participating in the evolving, highly-automated ATC system must be an area of continuing effort for FAA. To this end, the FAA is presently establishing a flexible general aviation cockpit environment equipped

to study information presentation, workload, communications, and other human factors problems in the context of low-cost, limited-crew operations. This facility is being developed at NAFEC and forms part of the joint NASA/FAA full-system simulation capability described above.

Cockpit Alerting Systems Standardization

The use of a broad spectrum of visual, aural, and tactile alerts in current generation jet transport aircraft, combined with potentially inconsistent design philosophies for future cockpit alerting systems, has caused the FAA to undertake an effort to bring the three major jet transport airframe manufacturers and a business jet manufacturer together to develop design guidelines for functionally standardized cockpit alerting systems. This project is expected to minimize such human factors problems as missed alarms, premature cancellations, confusion of alarms, erroneous responses to alarms, and the like, by reducing the number of alerts and functionally standardizing the major features of this flight critical system from aircraft to aircraft.

Head-Up Displays

Approach and landing continues to be statistically the most accident prone phase of flight. A frequent cause of such accidents are problems associated with the transition from electronic to visual guidance, particularly during low visibility conditions. Jointly with NASA, the FAA is currently investigating the advantages and disadvantages, in terms of safety during the approach and landing for civil jet transport aircraft, of combining precision electronic guidance information with visual information in front of the aircraft windscreen by the use of Head-Up Displays. This concept has been used successfully for some years by the military for air combat missions and is seeing limited use in Europe for approach and landing.

Collision Avoidance Displays

Significant problems exist with regard to the ability of pilots to see, interpret, and properly respond to collision avoidance information. FAA is currently studying pilot responses to various methods of presenting collision avoidance information in the cockpit, varying from simple alphanumeric displays to full electronic displays of traffic information.

Like other disciplines such as electronics and structures, human factors is an element of almost every research project conducted by FAA. The projects described above, however, constitute the majority (although not all) of the FAA's projects which relate primarily to minimizing human error in the cockpit. Other APEER projects underway are examining pilot training, visual guidance, and other areas which might contribute to reduced pilot error.

Equally as important to aviation safety as reducing pilot error is the requirement to minimize controller errors. The FAA is currently developing a controller human factors program known as the Controller Performance Enhancement and Error Reduction (CPEER) program, to complement the pilot-oriented APEER program. Many of the projects described above will be executed with parallel projects to investigate controller problems and, in particular, the full-system simulation capability will permit controller studies to be conducted in a full-workload environment with real pilots and procedures.

MILESTONES

Cockpit Information Requirements Analytical Study

Award contract - 2nd quarter FY-1979
Complete Phase I (Information Breakdown Structure)-3rd quarter FY-1979
Complete Phase II (Collation of Requirements)-1st quarter FY-1980
Complete Phase III (Cockpit Integration Impact)-2nd quarter FY-1980

Cockpit Systems Integration

Complete planning with NASA - 4th quarter FY-1979
Begin conventional aircraft studies - 1st quarter FY-1979
Complete Information Requirements Analytical Study - 2nd quarter FY-1980
Begin advanced aircraft studies - 3rd quarter FY-1980

General Aviation Human Factors Study

Award contract - 2nd quarter FY-1979
Complete study - 2nd quarter FY-1980

Full-System Simulation

Complete simulation plan - 2nd quarter FY-1979
Complete wide-body cockpit simulator - 4th quarter FY-1979
Complete narrow-body cockpit simulator - 1st quarter FY-1980
Complete general aviation cockpit simulator - 4th quarter FY-1979
Complete ATC interface - 2nd quarter FY-1980
Complete flight test capability - 2nd quarter FY-1980

Pilot Workload Assessment

Complete workload definition studies - 1st quarter FY-1978
Award grant - Massachusetts Institute of Technology - 2nd quarter FY-1978
Complete draft subjective scale - 2nd quarter FY-1979
Complete subjective scale refinement - 4th quarter FY-1979
Begin subjective scale validations - 1st quarter FY-1980

Computer-Aided Decision Making

Award grant - University of Illinois - 1st quarter FY-1979
Complete flight crew interviews - 4th quarter FY-1978
Complete wide-body system test bed - 3rd quarter FY-1979
Complete artificially-intelligent software - 4th quarter FY-1979

MILESTONES (Continued)

General Aviation Human Factor Research Laboratory

Complete systems design - 2nd quarter FY-1979
Install electronic displays - 3rd quarter FY-1979
Install human factor instrumentation - 3rd quarter FY-1979
Initiate first human factor studies - 4th quarter FY-1979

Cockpit Alerting Systems Standardization

Award contract - 2nd quarter FY-1979
Complete design studies - 3rd quarter FY-1979
Complete hardware designs - 1st quarter FY-1980
Complete competitive testing of concepts - 2nd quarter FY-1980

Head-Up Displays

Basic vision studies - 4th quarter FY-1978
Flight tests - 1st quarter FY-1979
Simulator studies - 2nd quarter FY-1979
Full-mission studies - 4th quarter FY-1979

Collision Avoidance Displays

Award contract - ARINC Research - 4th quarter FY-1978
727 Simulator studies
- Phase I - 1st quarter FY-1979
- Phase II - 2nd quarter FY-1980